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DISTRIBUTION PATTERNS OF *Macrobrachium rosenbergii* RELATIVE TO THE PRESENCE OF COVER STRIPS

Report No 87-136-K

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Abstract

The responses of adult *Macrobrachium rosenbergii* to the presence, absence and location of artificial cover strips in four different configurations were studied in aquaria. The animals displayed a strong preference for the cover strips. When strips dangling from the surface were presented, the animals could be induced to occupy the upper half of the water column at densities nearly 4.5 times higher than in a bare tank. Strips extending from the surface to bottom also resulted in a significant redistribution of animals. The animals associated with cover strips tended to favor horizontal surfaces such as those found at the tips of strips and at the bottom. The success of cover in redistributing the prawns appeared to be negatively influenced by the presence of dominant males who maintained a number of smaller animals herded in the corners of the aquaria.

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EXECUTIVE SUMMARY

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If prawns are to be raised in intensive thermal aquaculture schemes techniques will have to be developed for maximizing the utilization of the warm water volume available. Adult prawns are typically bottom living animals, thus production by existing culture methods is limited by the surface area available for colonization in the pond's bottom. An earlier aquarium study concluded that juvenile prawns will move into the water column if cover is provided. The present study attempted to determine whether adult animals can be induced to occupy the water column and to assess the strength of the affinity for the substrates that were provided.

The presence of strips in the upper half of the aquaria resulted in an average relocation to the upper half of 45 to 49 percent of the animals. The presence of cover on the aquaria bottom significantly increased the number of animals residing in the bottom half of the aquaria over the bare aquaria treatment. The net results were that when cover was provided off of the bottom an even distribution of animals throughout the water column was achieved. The broadest distribution was observed when cover was provided in the upper half the water column, followed by cover throughout the water column. Re-analysis of the data of a previous study with juvenile animals demonstrated that cover could be used to redistribute animals in the horizontal plane.

In the presence of strips the animals displayed a strong preference for occupying horizontal surfaces such as the tips of strips. Major variations were observed in the degree to which the prawns could be redistributed in the treatment with covers in the top half of the aquaria. The observed variations were attributed to the presence of dominant males which were observed herding several smaller animals (presumably females) along the aquaria bottom and prevented movement onto the cover strips.

The results of this study, coupled with a previous similar study on juvenile animals, indicate that cover can successfully redistribute the

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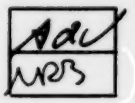
prawns throughout the water column. However, because of the herding behavior exhibited by mature males, an effort needs to be made to identify the optimum cover configuration which will provide sufficient large horizontal surfaces and will maximize the spread of the prawns.



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TO: Dr. D. Mills
Director of Research

DISTRIBUTION PATTERNS OF Macrobrachium rosenbergii RELATIVE TO THE PRESENCE OF COVER STRIPS

INTRODUCTION

Late in 1984 the Biological Research Section identified the Malaysian prawn Macrobrachium rosenbergii as a species having potential for thermal aquaculture schemes. The projected high yields and market values, its large size, its rapid growth, its requirement for warm fresh water in the growth phase, and the fact that it already is commercially grown at warmer latitudes all were taken as positive indicators. On the basis of these indicators it was decided to carry out a series of investigations to determine the feasibility of raising these prawns in Ontario with warm water supplied by Ontario Hydro's generating facilities.

The Malaysian prawn is widely grown under such names as giant prawn, giant freshwater prawn, giant Malaysian prawn, and freshwater prawn. The commercial methods of raising prawns in North America and the Middle East are through extensive aquaculture techniques; that is, the prawns are raised in shallow, bare, naturally heated, earthen ponds with a minimum of management, although supplementary feeds are provided. Yields of 3000 kg/Ha are not uncommon. However, higher yields should be attainable using intensive culture techniques.

In previous studies Smith and Sandifer (1975) found that the addition of cover in experimental situations enhanced the survival of prawns in the postlarval and juvenile stages. In fact some of the commercial growers in Hawaii place frames of synthetic webbing in their nursery ponds to enhance survival. Cohen et al (1983) and Ra'anan et al (1984) concluded from their research in Israel that providing additional cover in growout ponds may increase the yield of Macrobrachium. The best yield that they obtained was comparable to the high yield reported for Taiwanese farms which do not use cover but emphasize the control of the water quality (Cohen et al (1983).

It was postulated that the low production achieved by commercial growers may be due to the limited substrate available for animals to colonize in the bare earthen ponds which can be essentially considered to be two dimensional. The assumption was made that if greater use of the third

dimension, the water column, could be induced then it may be possible to increase the stocking density and ultimately production.

An earlier study demonstrated that use of the upper half of an aquarium's water column by juvenile prawns can be enhanced by over 400% by providing surface cover (Ontario Hydro Research Division Report No 86-267-K). The study was run for seven weeks. A significant increase in relocation of animals to the surface was demonstrated for the first two weeks, but although the redistribution continued, the degree of effectiveness was reduced for the last four test weeks. Casual laboratory observations by investigators in ongoing studies suggests that as the animals get larger and older they are less likely to move to the near surface area, and only do so during molting. If so, the provision of cover strategy at the surface may only be useful during the juvenile phase.

The present study attempted to determine if adult prawns (approximately one year old) exhibited a measurable preference for cover, and whether this preference could be exploited to redistribute the animals in test aquaria.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN

One-year-old prawns from post larval stock obtained from Amorient Aquafarms Inc. of Kahuku, Hawaii, and reared in a communal tank, were used for this study.

The experiment consisted of 12 aquaria divided into four treatments of three replicated aquaria each. Each aquarium was randomly allocated to a treatment, and lined on three sides with opaque plastic sheeting to avoid visual influence from other aquaria.

The four treatments were:

Treatment 1 - clear tanks
Treatment 2 - tanks with six substrate strips suspended from surface
Treatment 3 - tanks with six substrate strips resting on the bottom
Treatment 4 - tanks with six substrate strips suspended from the surface and six on the bottom

Each aquarium contained ten animals selected randomly from a pool of animals weighing 20 to 25 gm. All animals were replaced at the end of each week.

Cover to provide visual screening between animals as well as attachment surfaces was offered in the form of cover strips. The cover strips consisted of flat PVC material (45 cmL and 6 cmW) bent into compressed

sinusoidal shapes (roughly two cycles per strip) with a total overall length of approximately 20 cm.

The animals were fed unsupplemented commercial pelleted shrimp feed (Rangen Shrimp Grower) twice daily at roughly 5% estimated biomass, once before 0900, and once after 1500. Temperature was maintained at 27-30^{0}C and monitored daily prior to the initiation of observations. Lighting was roughly 8/16 light dark with light at 0830 and darkness by 1630.

New animals placed in aquaria were allowed to acclimate for two days prior to commencement of the observations.

OBSERVATIONAL PROCEDURE

Observations were gathered daily at fifteen-minute intervals during the periods of 1000-1200 hours and 1300-1500 hours. Results of the juvenile study showed no effects of feeding on distribution after half hour following feeding. An observer noted and recorded the distribution of the animals in each aquaria on prepared entry sheets.

The following observations were recorded:

total numbers in aquarium
numbers in top half of aquarium
numbers on cover strips in top half of aquarium
numbers in bottom half
numbers on cover strips in bottom half of aquarium
numbers on top of strips on bottom half of aquarium

In addition, notes were kept for the presence of herding males in the treatment with top strips.

The study was to be carried out over three discrete five-day periods; however, system failures resulted in data being collected for two periods of two days, and a third four-day period.

STATISTICAL TREATMENT

The distribution data were expressed as percent of the animals found in specific portions of the tanks. The inverse sine transformation was applied to the data used in all analysis of variance (ANOVA) and T-tests. This transformation is recommended when percentages cover a wide range of values (Steel and Torrie 1960).

The BMDP-PC 2V Repeated Measures ANOVA was used to compare the percentage of animals occupying the top half of the water volume. In the analysis treatment, replicates and sampling cycles were included as factors. The Two-Sample Analysis (T-tests) procedure found in the Statgraphics Package (STSC Plusware) was used to test for significant differences between proportion of animals found in top and bottom half of the aquaria. Multifactor ANOVA procedure followed by the Least Significant Difference

(LSD)(P=0.95) procedure with treatment and replicates as factors procedure found in the Statgraphics Package (STSC PlusWare) were used for all other analyses for which significance is stated.

RESULTS

DISTRIBUTION IN THE VERTICAL PLANE

A summary of the observations regarding the distribution of the animals in the four treatments is shown in Table 1. 49.5% of the animals in the treatment with surface cover strips were found in the top half of the aquaria, followed by the treatment with strips on both top and bottom with 44.8%, the bare aquaria with 9.3%, and the treatment containing bottom strips with 4.3%. The results of the ANOVA indicated significant treatment effects (P<.0001). The 95% LSD intervals suggested that all treatments were significantly different from each other.

TABLE 1

TREATMENT	NOS. OF OBSERVATIONS	HOMOGENEOUS GROUPS(LSD)	TOP	BOTTOM	T Test
BARE	440	A	9.3 (10.6)	90.7 (10.6)	***
BOTTOM STRIPS	440	B	4.3 (7.3)	95.7 (7.3)	***
BOTH STRIPS	440	C	44.8 (17.0)	55.2 (17.0)	***
TOP STRIPS	440	D	49.5 (19.9)	50.5 (19.9)	N.S.

Table 1. Overall mean and standard deviation (in parenthesis) of the percent of animals found in the top or bottom half of aquaria of each treatment. The treatments were found to be different (one way Anova, P=.0001) and all groups were identified as discrete entities using LSD 95% level. T test column shows the results of two sample tests of percent found on top vs. percent on bottom (H0:Diff=0).

A measure of the effectiveness of the vertical redistribution in the vertical plane is the relative proportion of animals in the two halves of the aquaria. If an even distribution was obtained, the means of the two

halves should not be significantly different, while deviations represent a preference for one half of the aquaria. In three of the four treatments the animals showed a significant preference for the bottom half of the aquaria; only the one with the strips in the upper half of the aquaria succeeded in evenly redistributing the animals (Table 1).

UTILIZATION OF COVER BY TEST ANIMALS

On the average 90.7% of the animals in the bare aquaria were on the aquaria bottom, and the remainder were found clinging to the air hose, or at the air water interface clinging to the netting covering the aquaria (Table 2).

Table 2

Utilization of Cover Strips by the Prawns

Treatment	% on Bare Surface	% Using Cover Strips	% in Strip Area Using Strips	% of Those on Strips Using Flat Surface	% Using Flat Areas (Strips + Bottom)
BARE	90.7 (10.6)	-	-	-	90.7 (10.6)
BOTTOM STRIPS	55.1 (19.7)	42.9 (19.7)	44.7 (19.7)	70.9 (24.4)	86.7 (21.5)
TOP STRIPS	50.5 (19.8)	45.1 (18.2)	92.1 (15.9)	U.K.	U.K.
BOTH STRIPS	30.5 (17.9)	69.5 (17.9)	69.5 (17.9)	64.6 (21.6)	75.4 (19.8)

Table 2. The distribution of prawns, mean and (S.D.), on the bare bottom of the aquaria and on the cover provided in each treatment.

The treatment with cover strips on the bottom resulted in an increased use of the lower half of the aquaria by the prawns to 95.7% (Table 1). Of those on the bottom half of the aquaria 44.7% (42.9% of the total) were found clinging to the cover strips, and of these 70.9% (or 31.6% of the total) occupied the horizontal surfaces provided at the top of the strips (Table 2). When one considers that there were only six horizontal platforms available per aquarium (tops of six strips) the preference for

horizontal surfaces becomes quite significant. In this treatment 86.7% of the prawns were found associated with the horizontal surfaces provided by either the tips of the strips or the bare aquaria bottoms.

The treatment with cover strips both suspended from the water surface and sitting on the bottom resulted in 69.5% of the animals associated with the strips. Of those associated with the strips 64.6% (or 44.9% of the total) were occupying horizontal positions at or in close proximity to the air-water interface.

In the treatment with surface strips 92.1% of the animals found in the upper half of the water column were associated with cover strips. In this treatment significant differences in distribution were observed between replicates and between three sampling cycles. In some of the cycles individual males herded four to five other animals into portions of the bottom and prevented other animals from approaching and presumably other members from leaving the bottom. The animals being herded were smaller in size, had small claws, and did not exhibit aggressive behavioural displays. Because of the above they were assumed to be females. Other smaller or less dominant males that were present in the aquaria tended to occupy the surface cover strips that were available. Notes on this behaviour were available for all three replicates during the first two cycles and two replicates during the third. ANOVA with the presence of dominant males as a factor and aquaria location as a covariate indicated a significant factor effect P<.0001). In aquaria with dominant males only 38.1% of the animals occupied the surface half, while in the absence of the herding behaviour 69.4% were occupying the top half of the aquaria (Table 3). Herding behavior was also evident in the bare aquaria, where virtually all of the animals were distributed along the aquaria bottom in one or two clumps.

Table 3

Experimental Conditions	Number of Observations	Average Percent on Top	Average Standard Deviation
A	216	38.1	14.5
B	144	69.4	14.4

Table 3. Percent of prawns occupying the upper half of the aquaria when A) Dominant males were present, and B) no dominant males identified.

REDISTRIBUTION IN THE HORIZONTAL PLANE

The above results show that the provision of cover results in the redistribution of animals in the vertical component of the water column; no attempt was made to observe the horizontal component. To address the horizontal component, data collected for the juvenile study (Ontario Hydro Research Division Report No 86-267-K) were re-examined. In the juvenile study the horizontal plane of the aquaria had been split into thirds, and observations were made on the distribution of the animals relative to each third. The data from the treatments consisting of bare aquaria, and aquaria with strips on the bottom and strips on the top were used.

As discussed previously (Ontario Hydro Research Division Report No 86-267-K) the prawns in the bare aquaria consistently displayed a preference for the sides of the aquaria containing the air hose and stone. The data were re-examined to determine if the presence of cover resulted in a more even distribution across the aquaria. The results from the two treatments, matched by air line and hose location, are shown in Table 4. The presence of cover strips along the bottom resulted in a significant and more even redistribution of animals.

Table 4

Treatment	Air Stone Location	Aquaria Thirds A	B	C
No Cover	A	<u>40.1</u>	31.1	28.8
Bottom Cover	A	<u>30.5</u>	35.4	34.0
Top Cover	A	<u>35.1</u>	31.6	33.2
No Cover	C	31.3	33.1	<u>35.6</u>
Bottom Cover	C	34.1	31.3	<u>34.5</u>
Top Cover	C	35.5	30.0	<u>34.5</u>

Table 4. The horizontal distribution of prawns (Percent of total) in three sectors of the aquaria wher. the air stone was located in the A) left third, and C) the right third of the aquaria. Locations where highest densities are expected are underlined. Means of 96 observations are shown.

DISCUSSION

Analysis of the distribution of prawns in this experiment shows that the adults continue to display the characteristic strong preference for occupying the bottom in bare aquaria that juveniles had shown. On the average, less than 10% of the animals in bare aquaria used the upper half of the water column, which shows no change from the distribution observed in the juvenile experiment (Ontario Hydro Research Division Report No 86-267-K). These in turn are consistent with Ling (1969) who described the animals as spending much of their time crawling along the substrate.

It was noted in the work with juveniles (Ontario Hydro Research Division Report No 86-267-K) that the animals could be induced to leave the bottom when cover strips were provided in the water column; however, in that study the effectiveness of redistributing animals with cover strips decreased with age. It was postulated that this change might have a negative impact on the usefulness of providing additional cover to redistribute animals into the water column during the late growout phase. The above premise was rejected in the present study, since the presence of surface cover strips resulted in continued use of the upper half of the water strips by approximately 50% of the animals.

The animals displayed a preference for occupying the bottom of the aquaria. The strength of the preference was significantly altered by the provision of cover in the form of cover strips. The cover strips served two functions, they provided additional surfaces to occupy as well as serving as screens between animals. In the presence of cover strips in the upper half of the water column the preference for the bottom disappeared. The animals seem to choose areas providing cover when it is available, and are partial to horizontal surfaces. The availability of cover allows for redistribution in both the horizontal and vertical planes. If these responses can be successfully exploited high density growout schemes may be possible.

Not all the animals responded in the same manner to the presence of cover. The exceptions were the dominant males with their herd. When cover strips were present in the upper water column these animals were always found at bottom of the aquaria. Since the cover strips did not provide space for more than one animal on any horizontal location, it is not known if these animals occupied the bottom out of preference or because no suitable platforms had been provided. Horizontal platforms may play an important role in prawn production; evidence for this is found in Smith and Sandifer (1975) who found that, in an experiment with juvenile prawns, habitats with extensive horizontal surfaces were found to be slightly more productive than habitats with vertical ones.

Results reflecting similar trends were also found in adult prawns grown in mesh cages containing both horizontal and vertical mesh partitions. Cages with both partitions were found to contain slightly more animals and substantially higher biomasses than cages with horizontal partitions, up to age of 38 weeks in a growout experiment lasting to 48 weeks of age

(Ontario Hydro Research Division Report No 87-31-K). It should be noted that the two above studies were primarily concerned with the addition of substrate rather than providing cover.

Little is known about space utilization by Malaysian prawns or the role that cover may play. Indications that juveniles in nature occupy the shelters provided by crevices and plants are described by Raman (1961). Peebles (1979) considered that cover in growout ponds may be a limiting resource. Nevertheless the provision of cover is not new in prawn aquaculture. Cohen et al (1983) and Ra'anan et al (1984) concluded that "substrate may improve yields either by reducing growth inhibition..., or by providing hiding places to newly molted and small individuals." Hawaiian prawn farmers routinely use cover in postlarval nursery ponds.

The present study demonstrated that provision of cover strips in aquaria resulted in animals being redistributed throughout the water column. However, the impact of the redistribution on survival and yield was not addressed. The results of studies based on increasing available substrates appear to suggest that growth and survival may be improved, whether the observed improvement is a result of redistribution is not known. The degree of improvement that is achievable will partly depend on the ability to optimize the cover configuration that will be provided.

CONCLUSIONS

1. The presence of cover was effective in redistributing the prawns relative to the bare aquaria.

2. The animals showed a strong selection for the cover. Presence of bottom cover reinforced the natural preference for the bottom, while presence of cover in the water column resulted in the movement of individuals into the water column.

3. The maximum relocation of prawns towards the upper half of the water column was achieved by the treatment with surface covers; 49.5% of the animals were relocated, followed by the treatment with cover throughout the water column at 44.9%.

4. Dominant animals with their herd typically do not relocate to the upper portion of the water column; this lack of response was attributed to an absence of suitable horizontal platforms in the cover that was provided.

5. Re-analysis of previous data suggested that presence of cover also improved the evenness of distribution in the horizontal plane.

6. Because there is evidence available in the literature that increasing the amount of substrates improves prawn production, investigations to maximize production through the redistribution of animals using varying combinations of adding surfaces as well as providing cover are recommended.

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